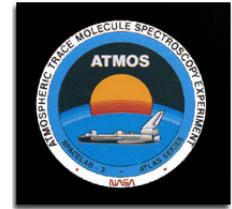


Using High Spectral-Resolution FTIR Measurements to Characterize SSA: Volume, Size, and Composition

Annmarie Eldering, Frank Mills,
Helen Steele, Brian Kahn

Thanks to Bill Irion, Mike Gunson, ATMOS group

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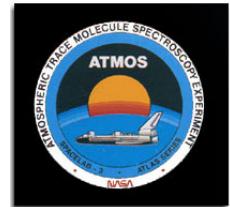
Game Plan

- Background of instruments
- Analysis technique for ATMOS
- Results from ATMOS
- Analysis technique for MkIV
- Results from MkIV
- Possibilities for ACE
- Summary



What are sensitivities?

- Loading (concentration)
- Composition
- Size
- Depends in instrument, viewing geometry, loading...
- Will focus on a demonstration of observed sensitivities
- MkIV
- ATMOS
- Application to ACE



ATMOS

- Farmer, Gunson
- Space shuttle
- Filters - vary bandpass
- Extensive trace gas retrievals

GEOPHYSICAL RESEARCH LETTERS
GUNSON ET AL.: THE ATMOSPHERIC TRACE MOLECULE EXPERIMENT (ATMOS) 2335

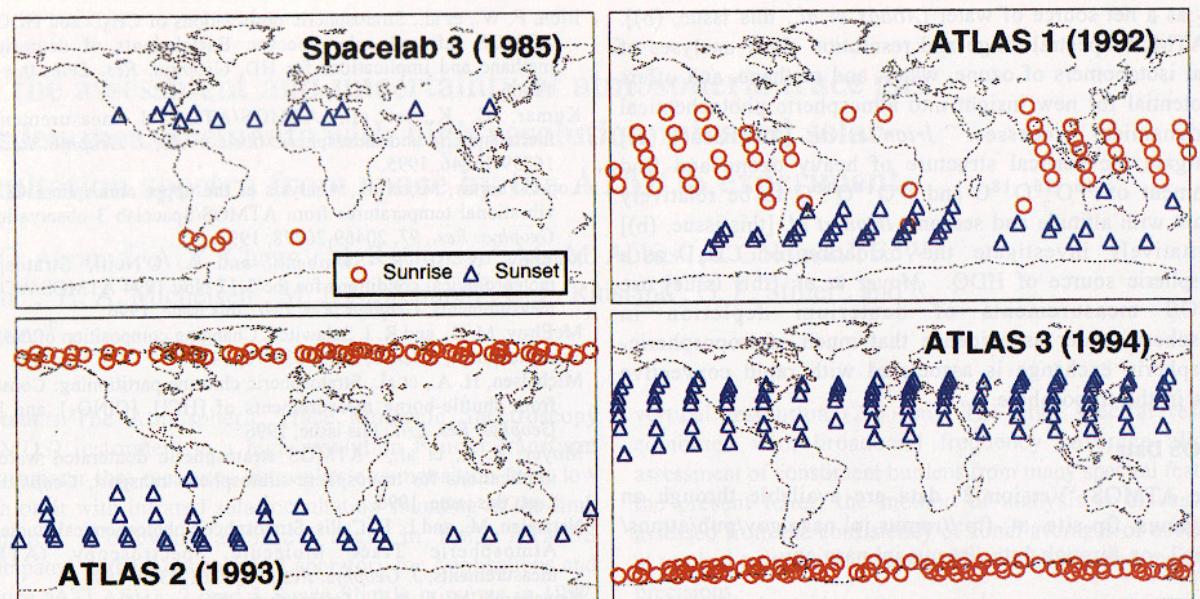


Figure 2. Sunrise (circles) and sunset (triangles) occultations observed by ATMOS on Space Shuttle for (a) Spacelab 3, 29 April-May 7, 1985; (b) ATLAS-1, 24 March - 3 April 1992; (c) ATLAS-2, 8 - 16 April 1993; and (d) ATLAS-3, 3 - 14 Nov 1994.



Analysis approach

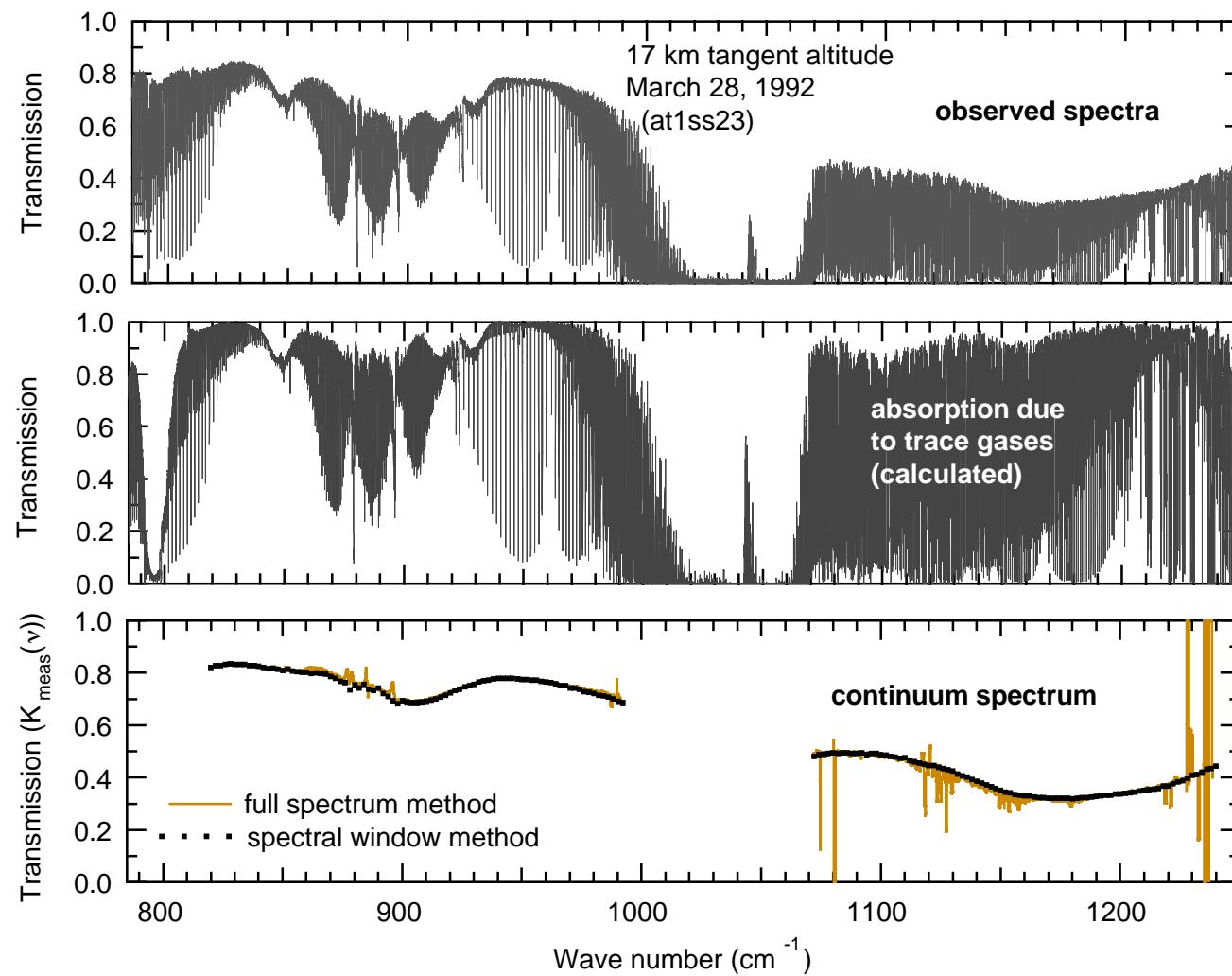
- Transmission (occultation) measurements

$$T = \exp(-k(\nu)Vds)$$

- Use retrieved gas profiles to calculate absorption due to gases
- In 2cm^{-1} windows, find avg T not accounted for by gases
- Over filter, this creates continua spectra
- Fit aerosol model to continua spectra



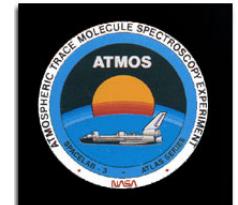
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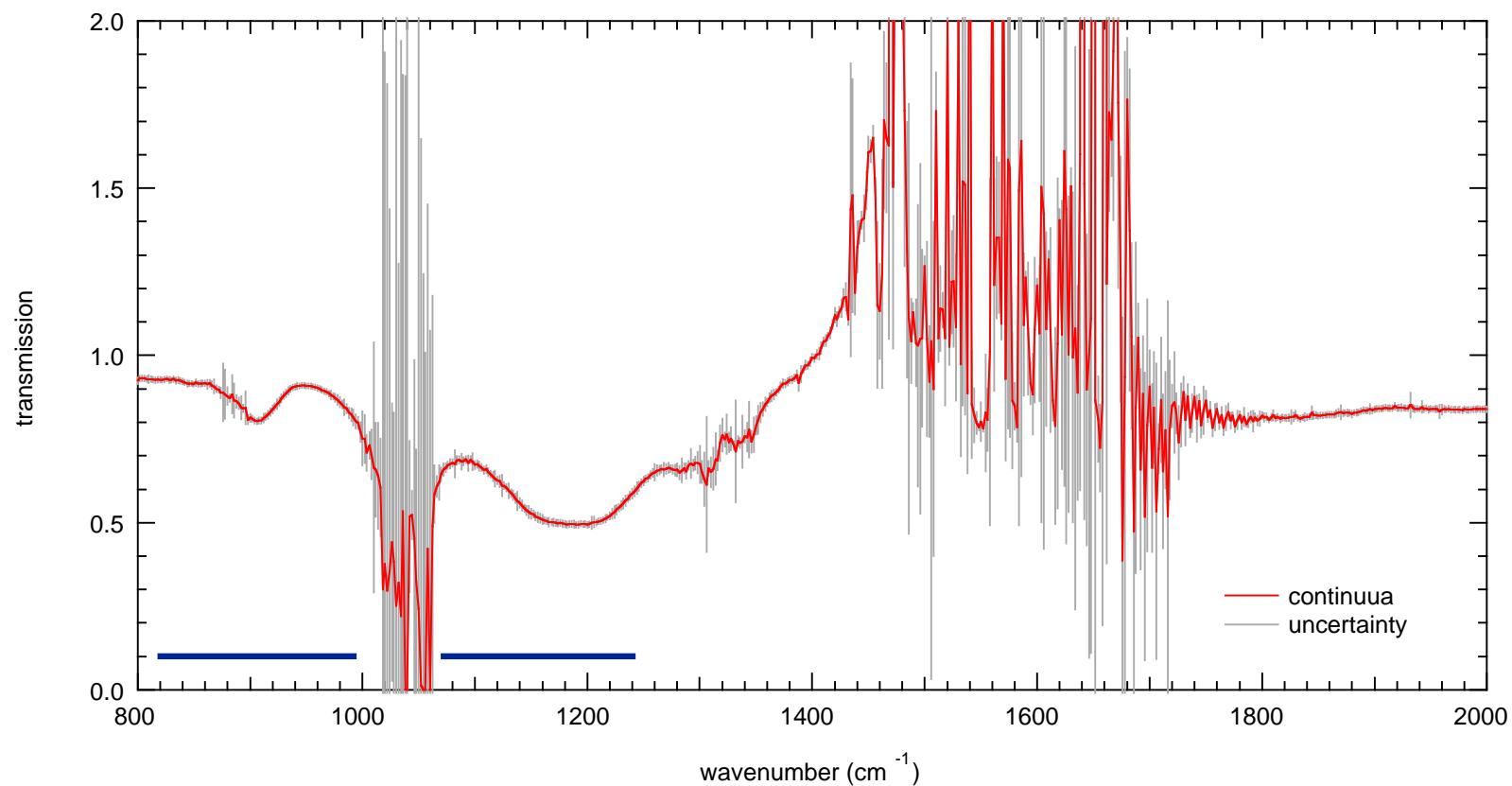
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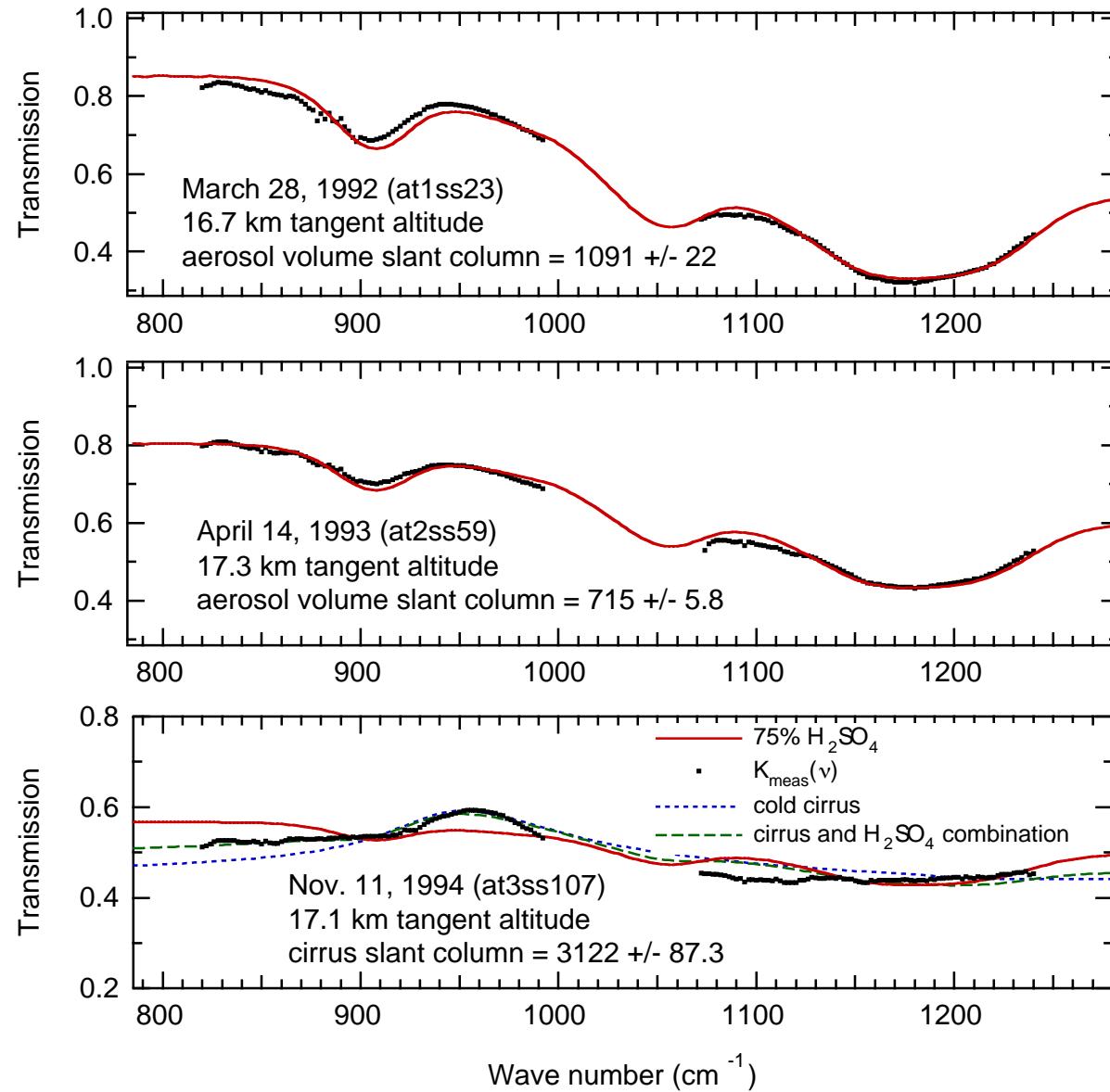
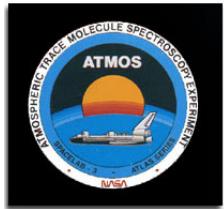
Fitting ATMOS spectra

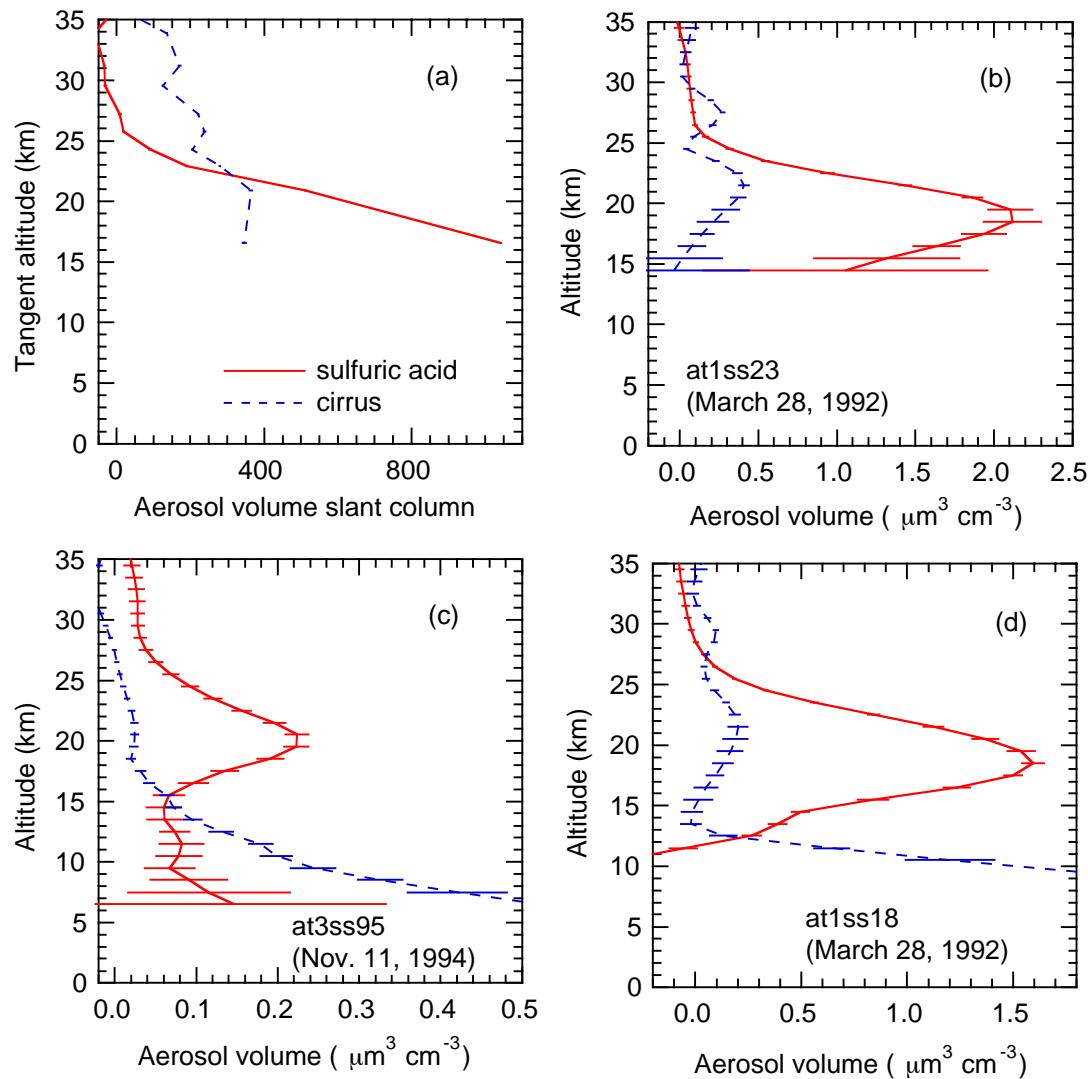


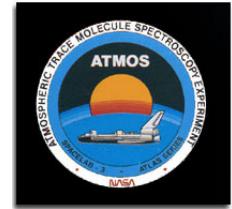
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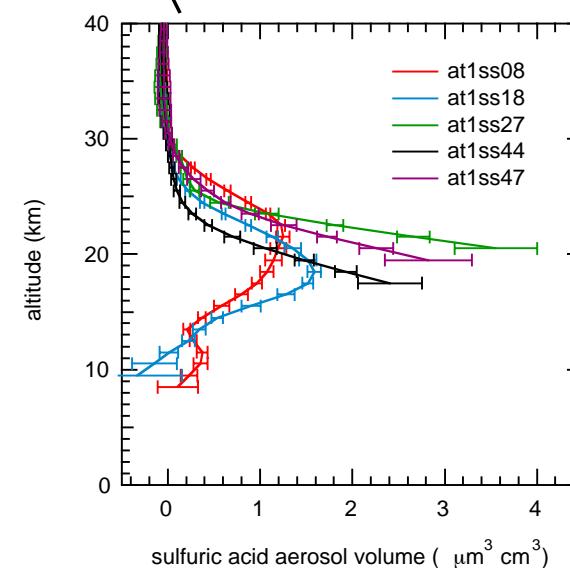
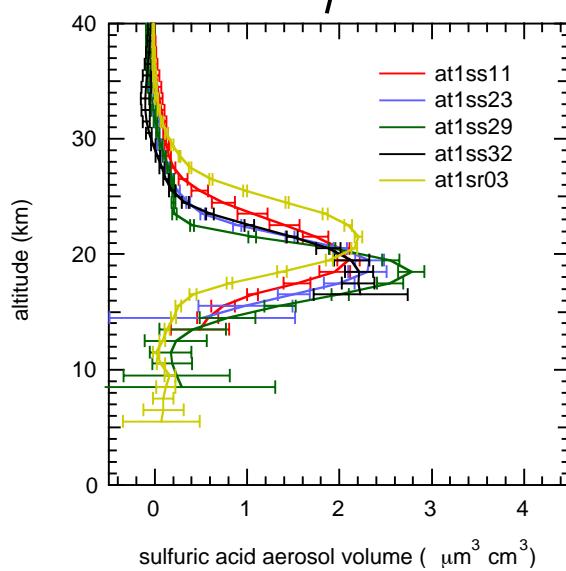
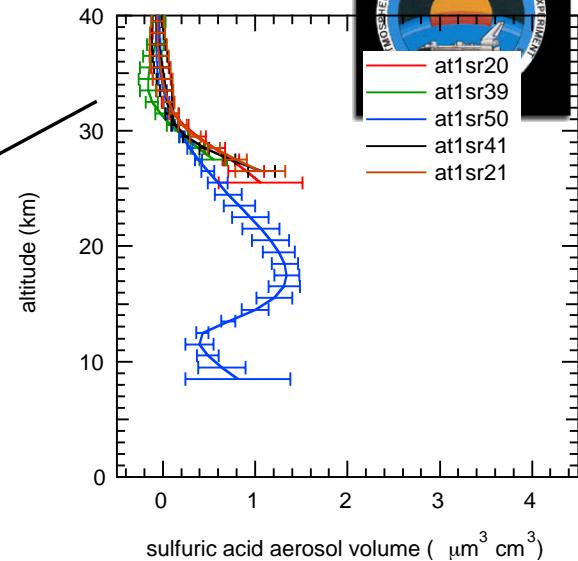
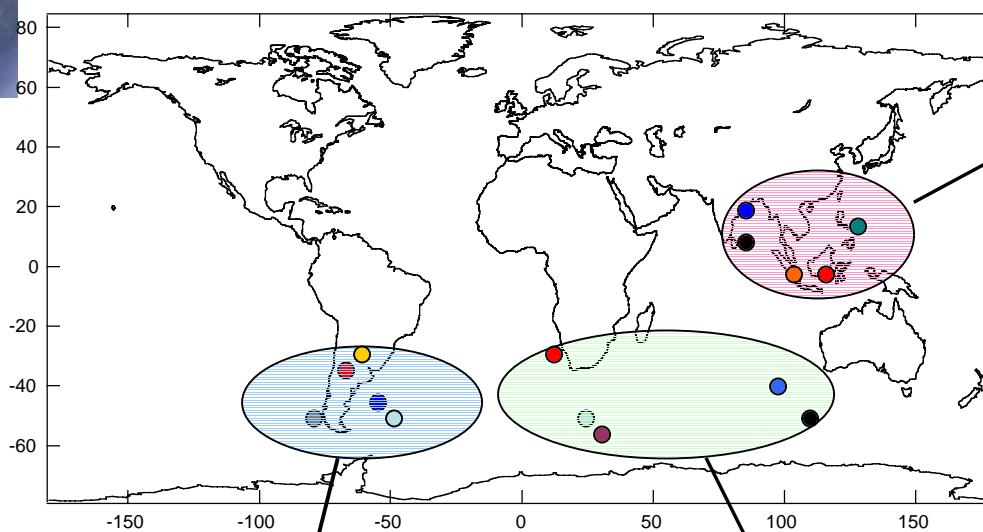


Volume retrievals

- Initial analysis in ATMOS retrieval framework
- Fix aerosol size distribution and composition, retrieval aerosol volume, invert to profile
- Profiles of aerosol volume compare well with other observations:
 - SAGE
 - ISAMS and CLAES
 - Balloon measurements



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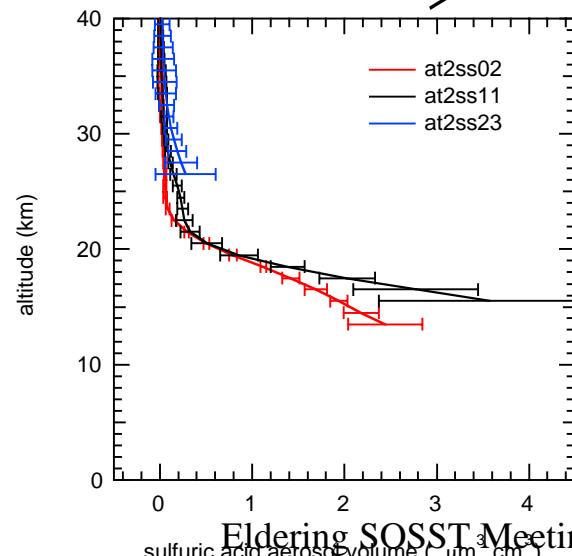
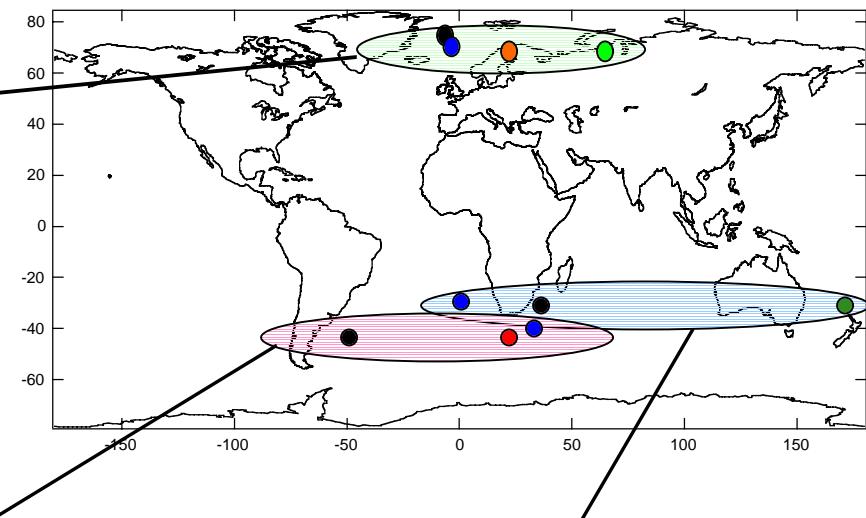
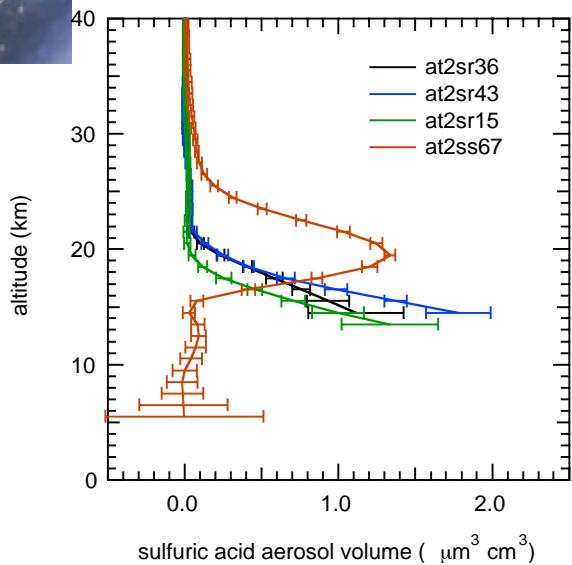


1992

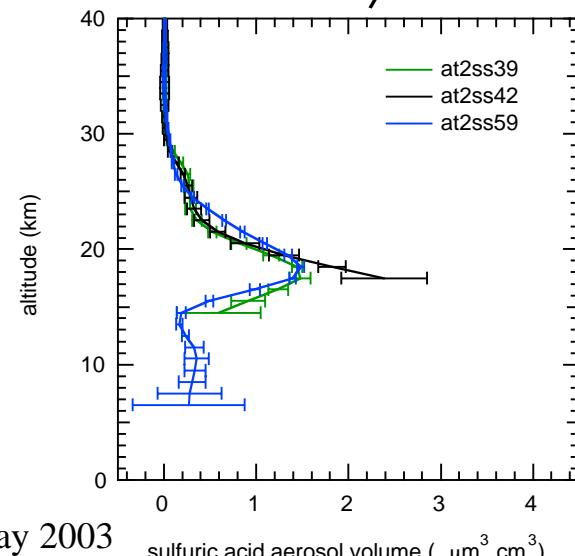
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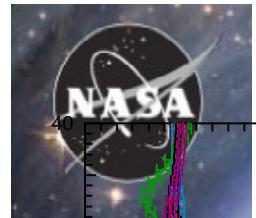


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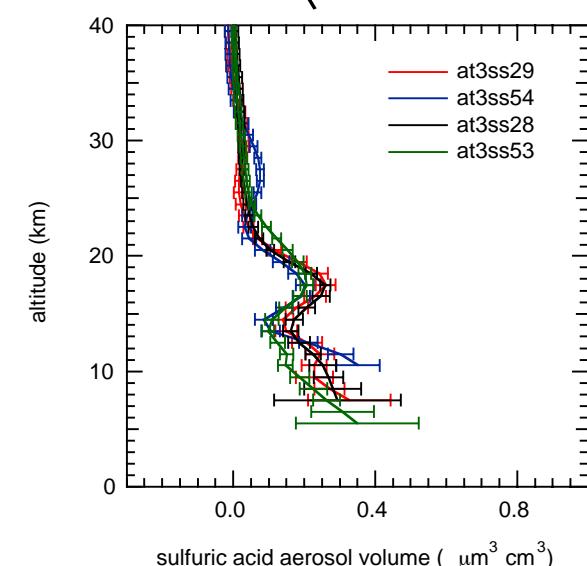
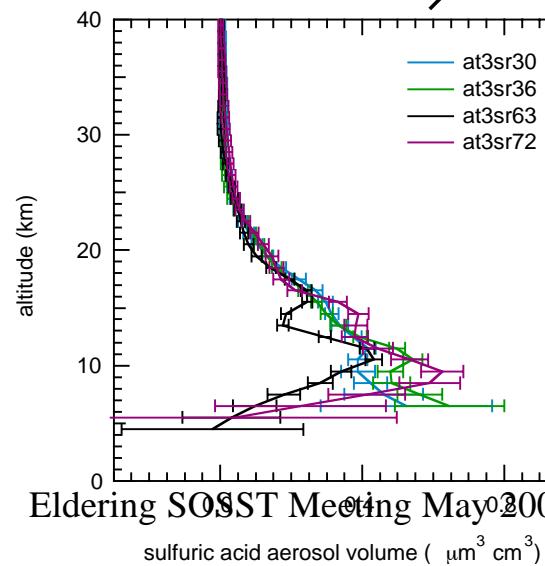
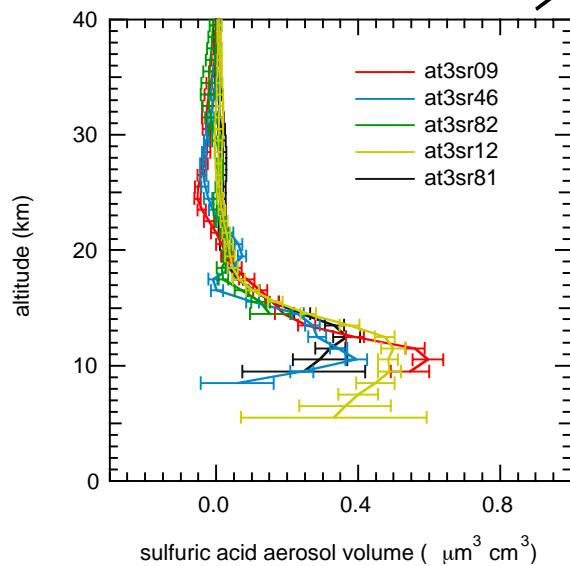
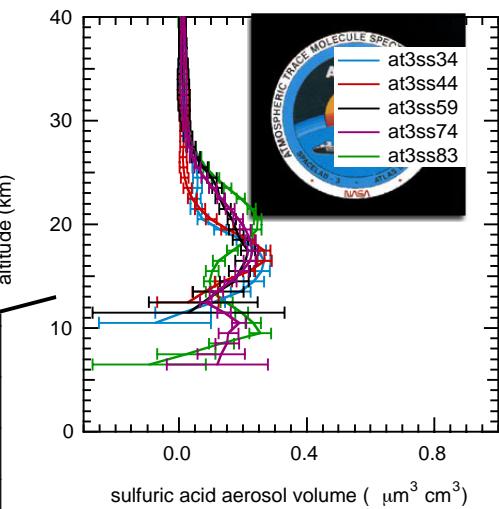
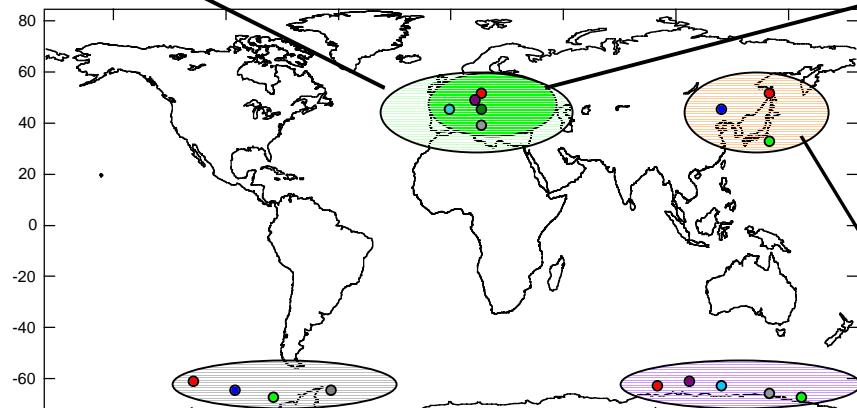
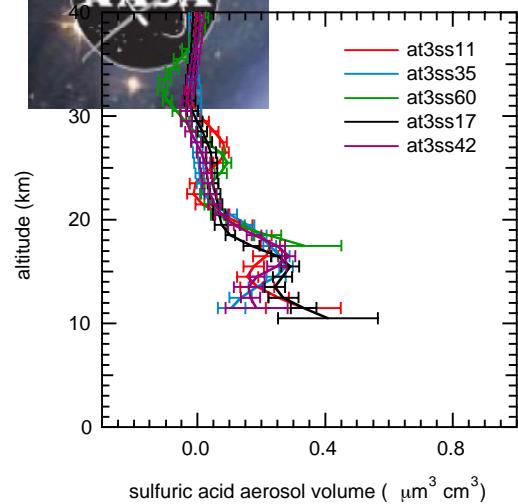
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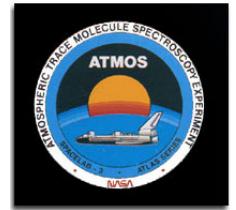


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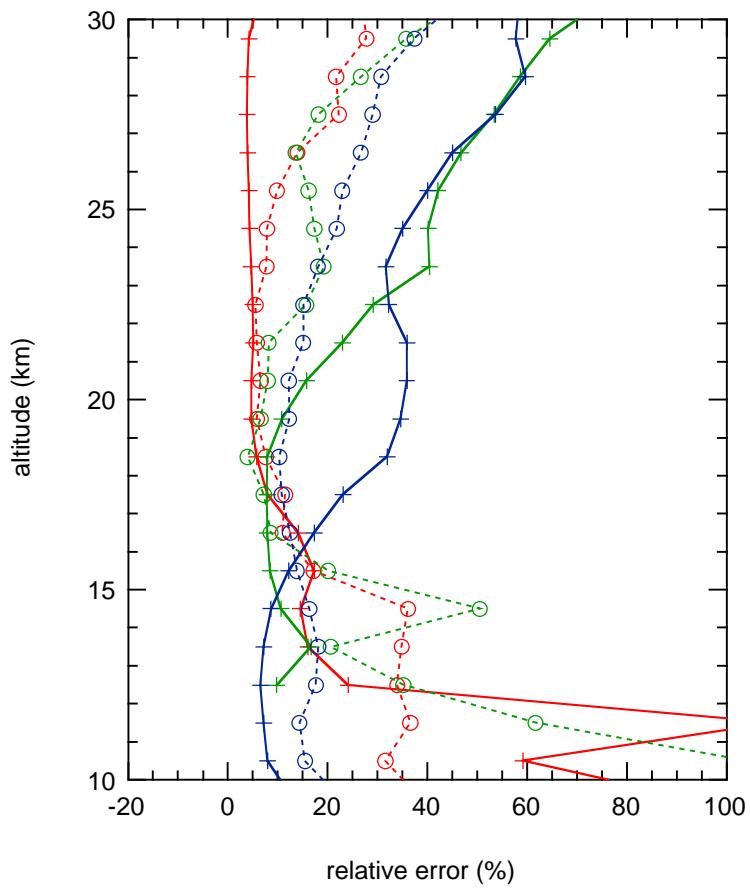
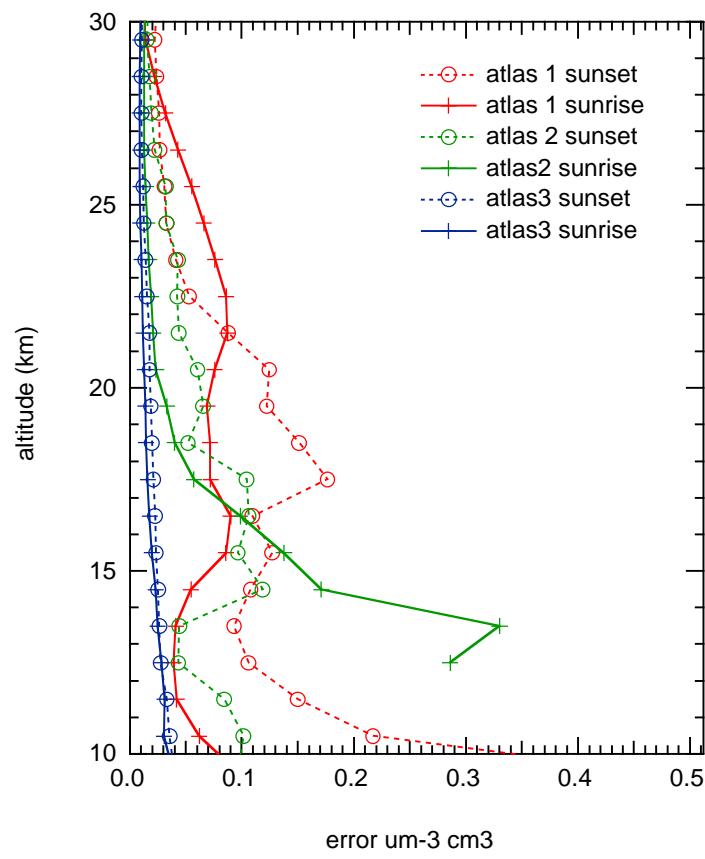
1994



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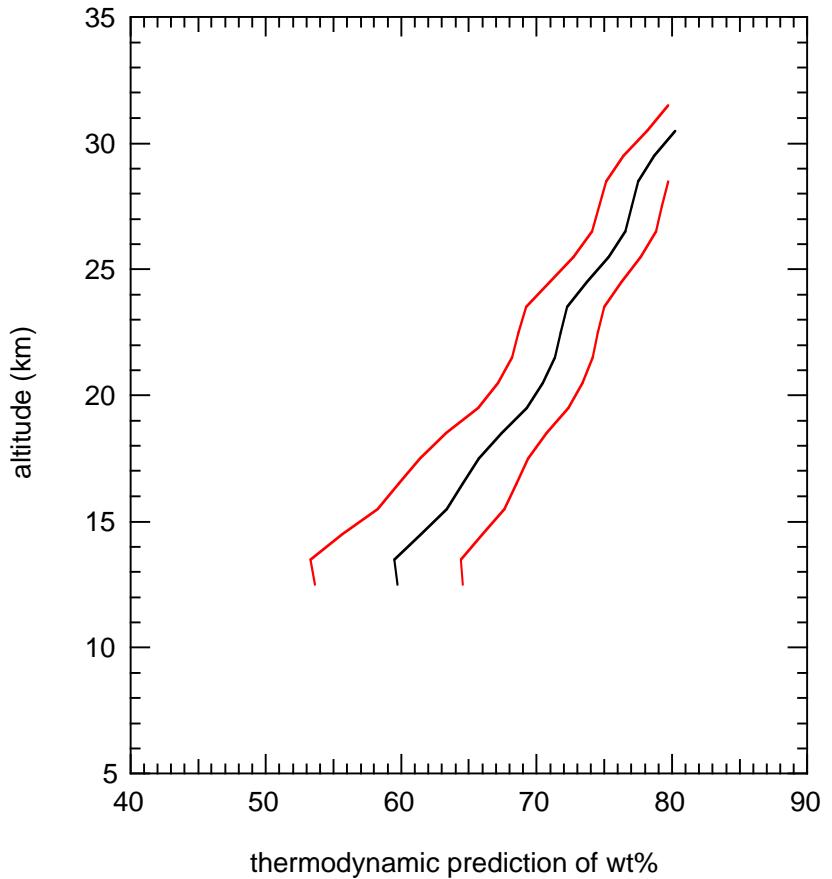
Error characteristics





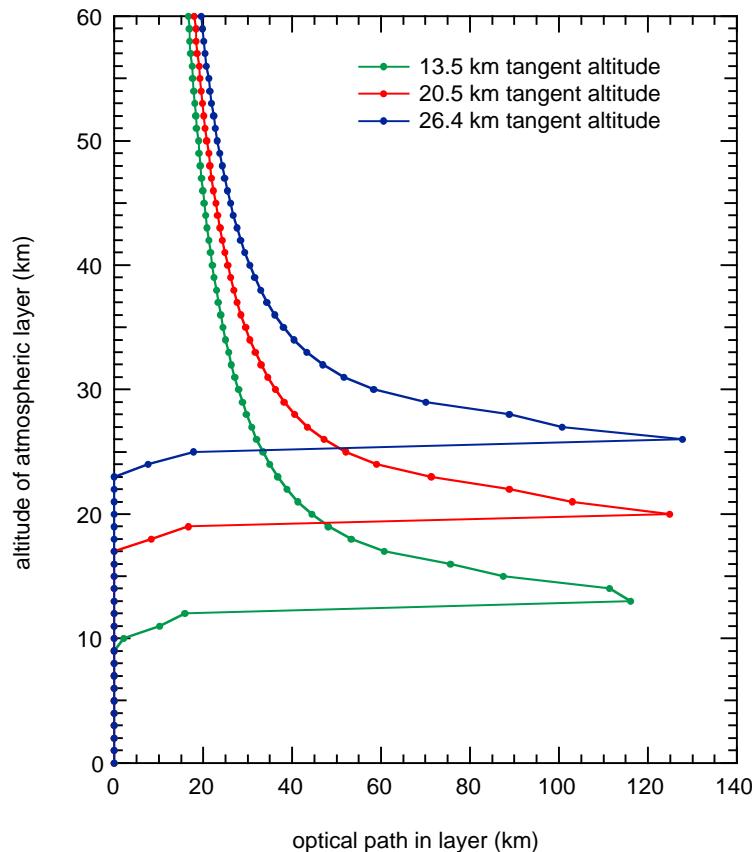
composition

- Thermodynamic models and ATMOS retrieved temperature and water are used to predict the vertical profile of aerosol composition
- Uncertainty through propagation of T and H₂O uncertainty

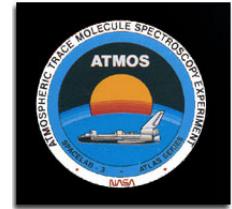




Comparable quantities



- ATMOS viewing geometry integrates through layers of varying composition.
- Will compare a composition that has been weighted by slant path and aerosol volume.

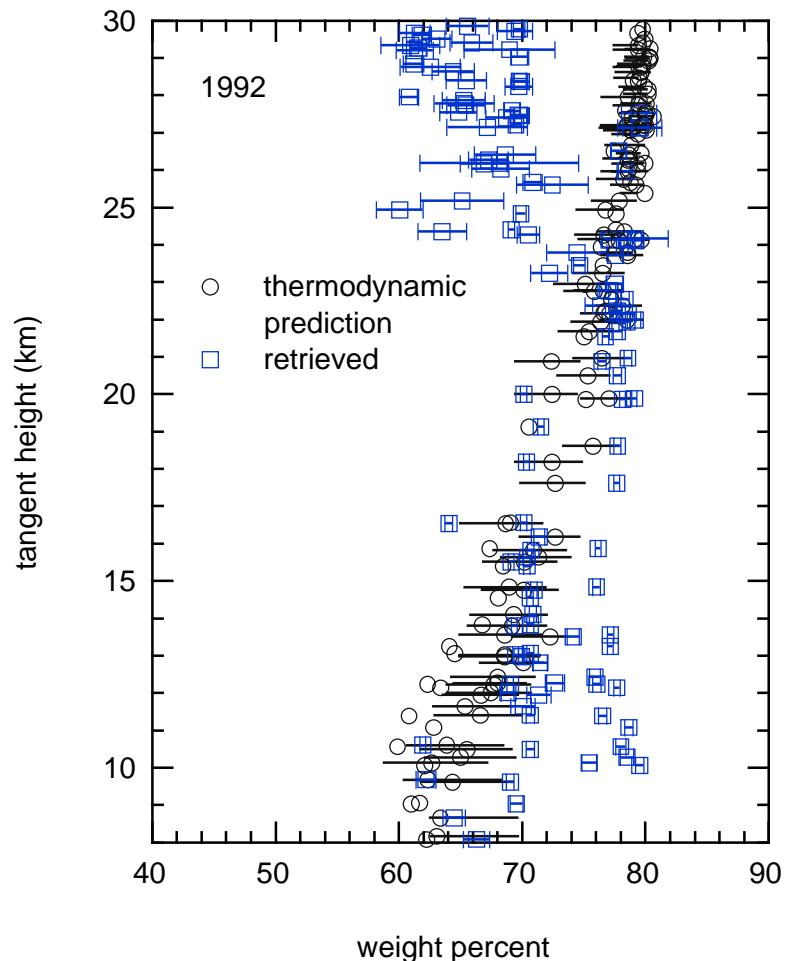


Retrieving composition

- Fix size distribution
- Fit aerosol volume simultaneously with composition
- Precalculate extinction for compositions from 60 to 80% in 1% increments
- Perform nonlinear least squares fitting, using finite difference Jacobians for weight percent



Retrieval results



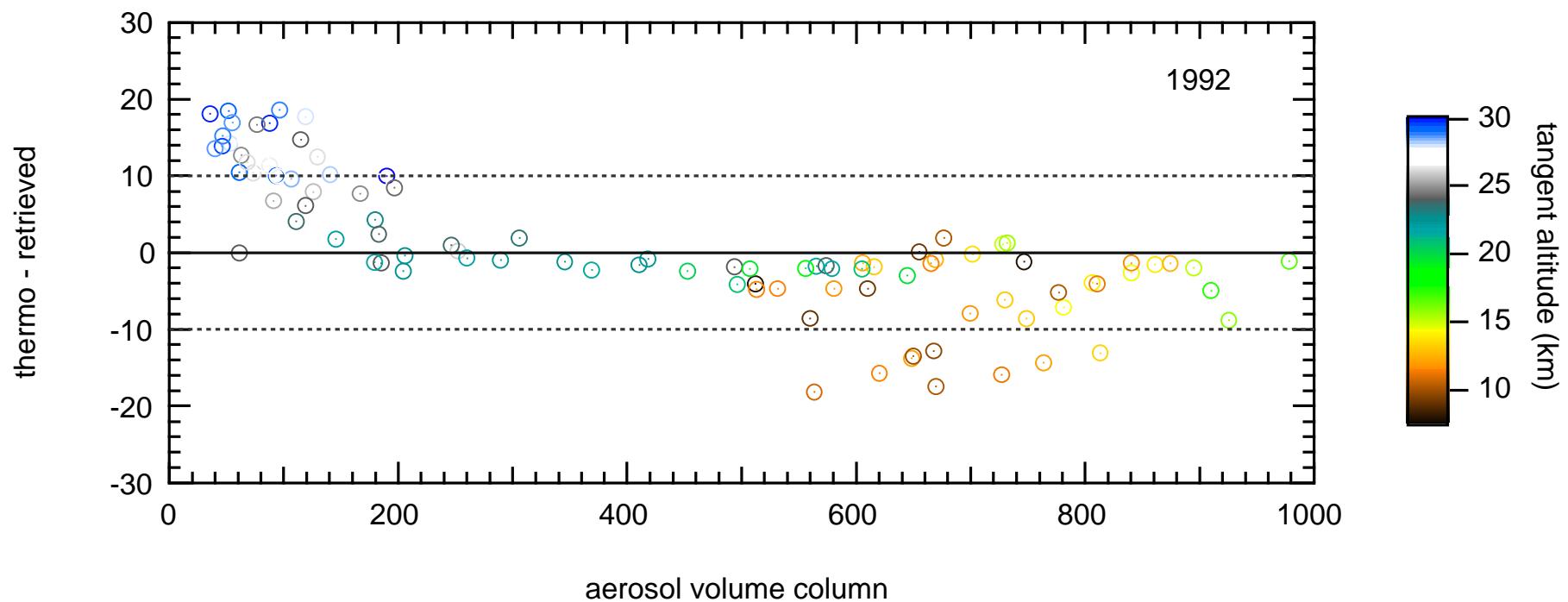
- Result - retrieved composition and uncertainty on composition at each tangent altitude



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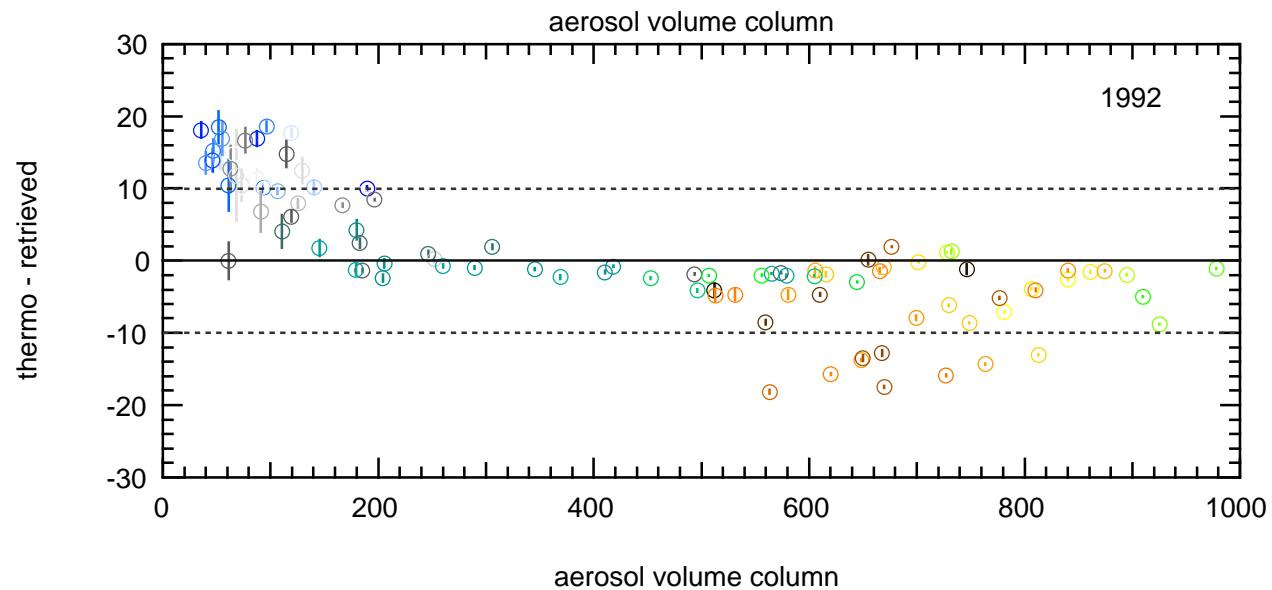
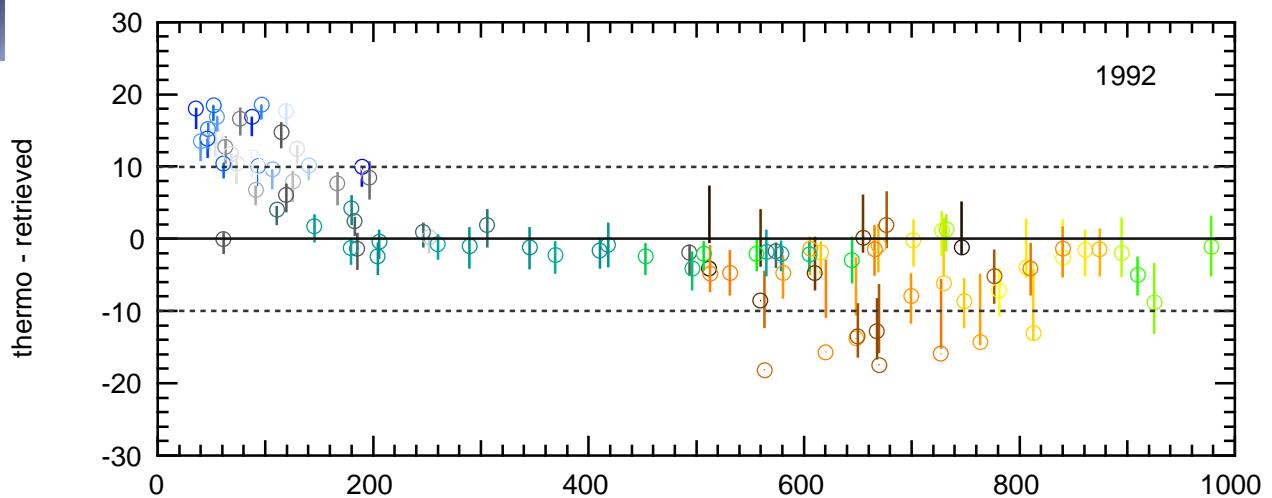
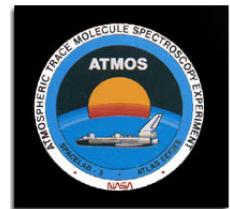
Retrieval results



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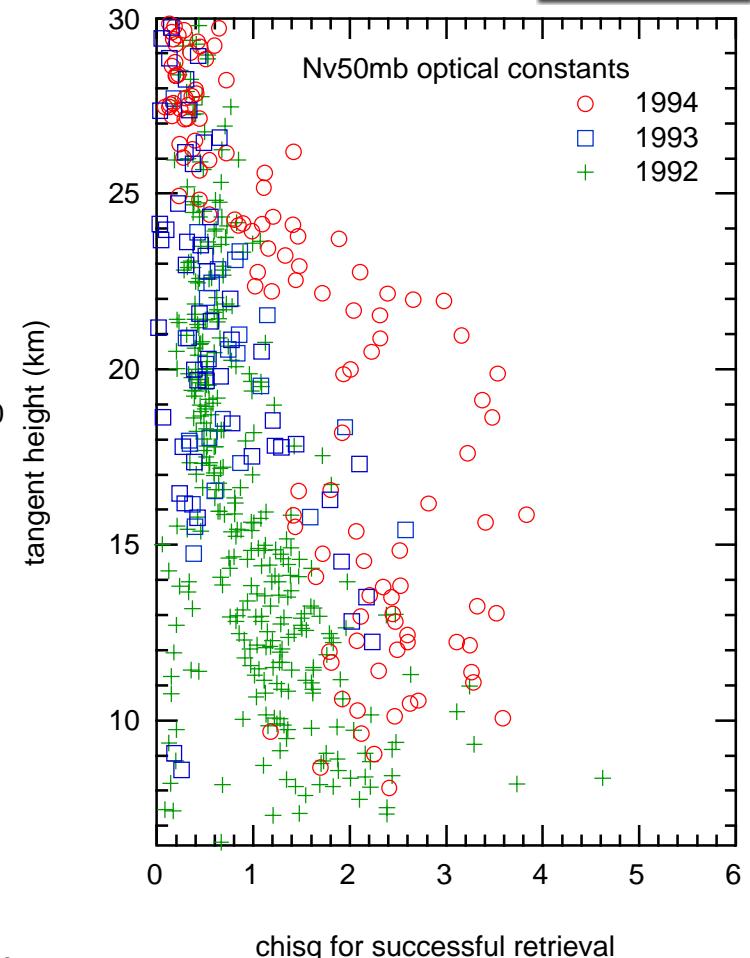
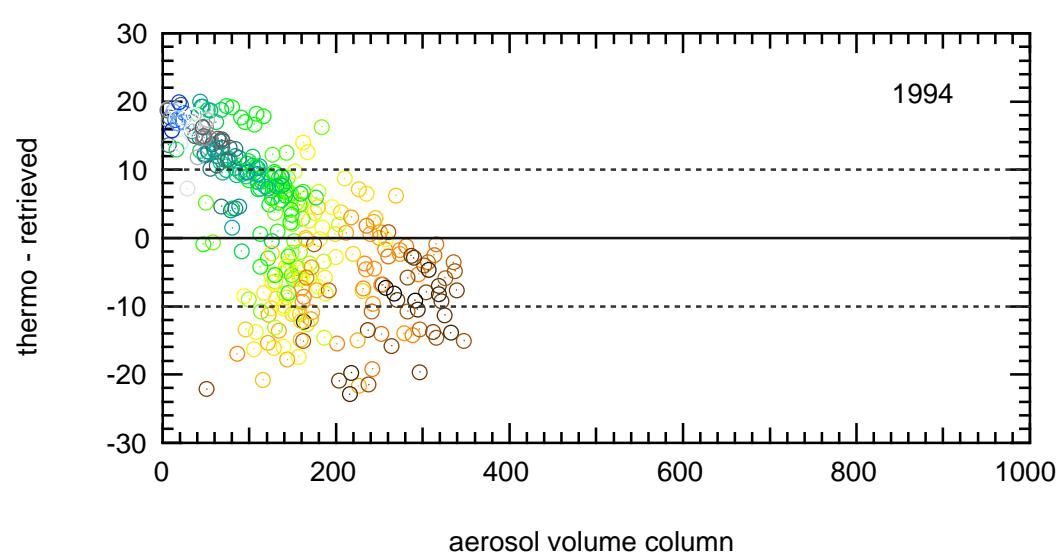
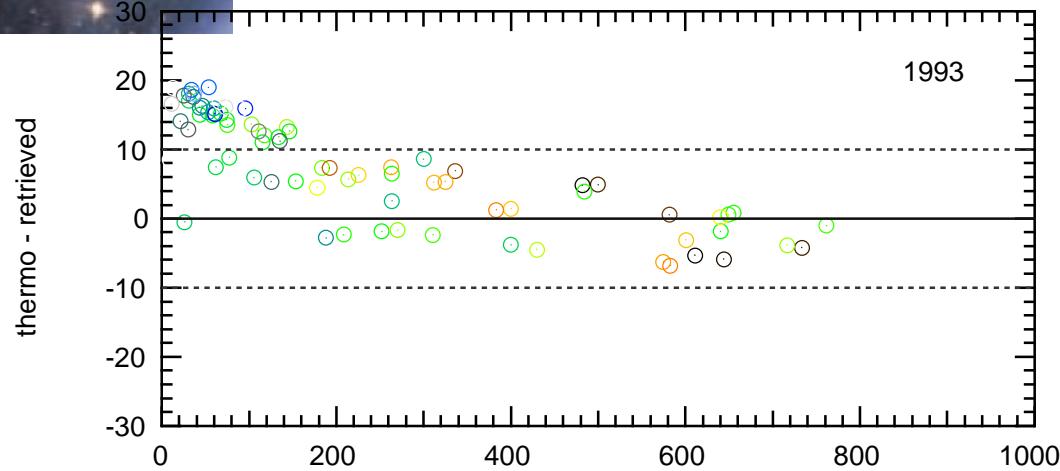
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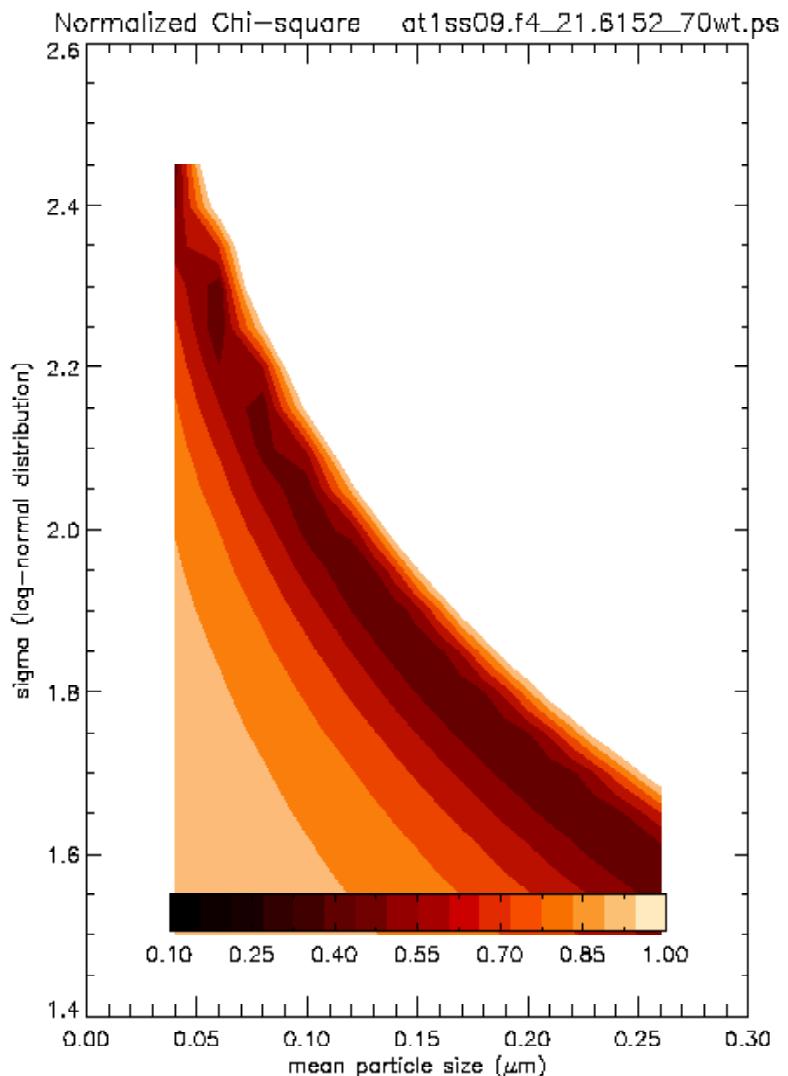
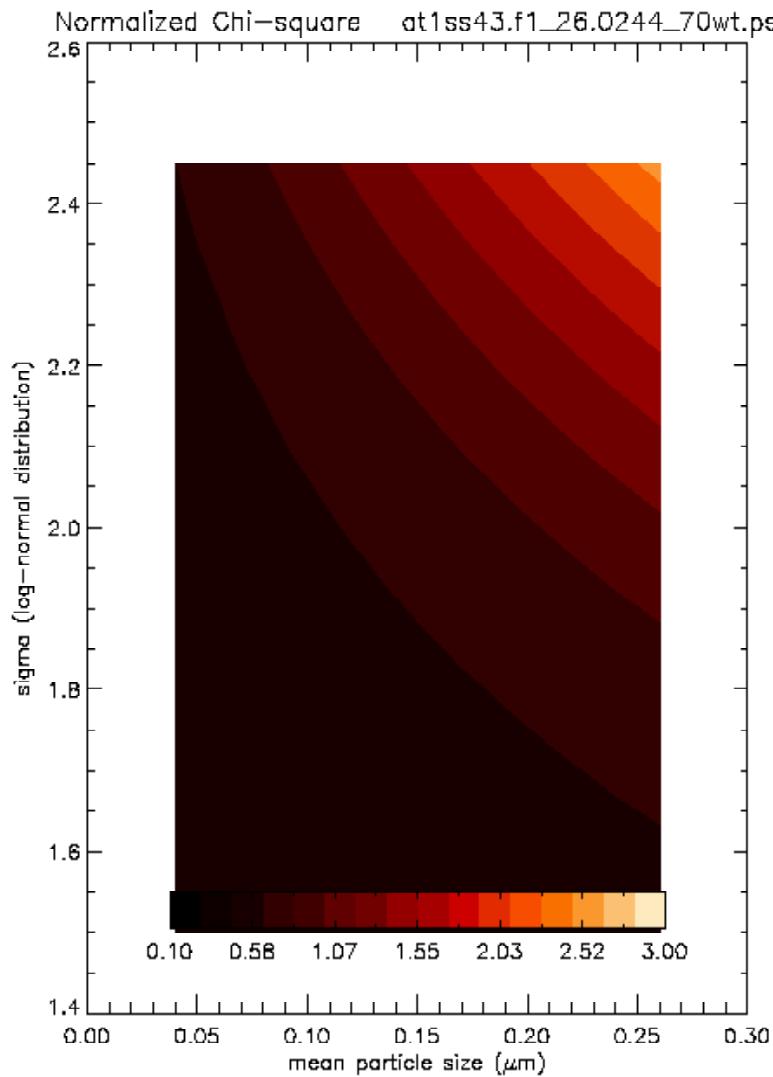
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Size sensitivity

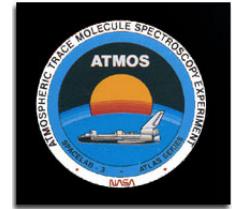




MkIV FTIR

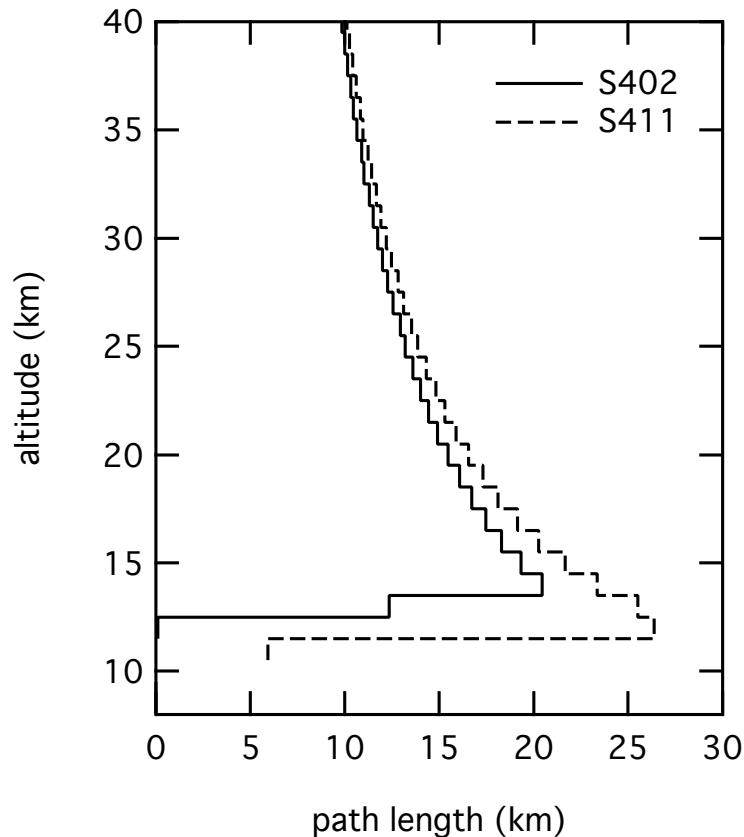
- Geoff Toon is PI
- Balloon and aircraft
- Covers 650-5650 cm⁻¹
- Focus on 1992 AASE II flights
- Will focus on stratospheric sulfuric acid aerosols

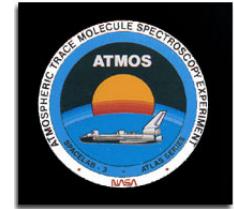




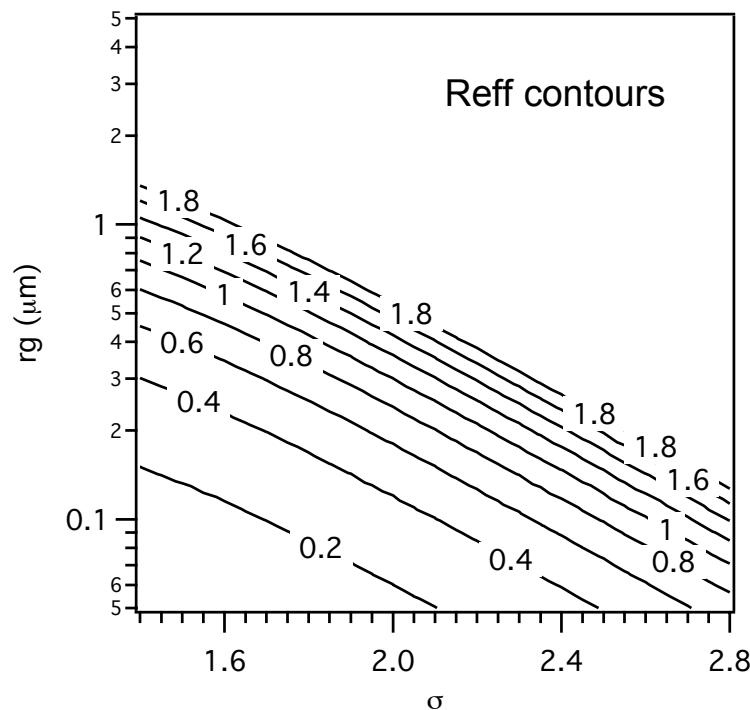
More on MkIV

- Normalize spectra with near zenith measurement
- Use retrieved gas profile to remove gas effects and see aerosol
- Examine fit between observation and set of aerosol models
- No vertical profiles





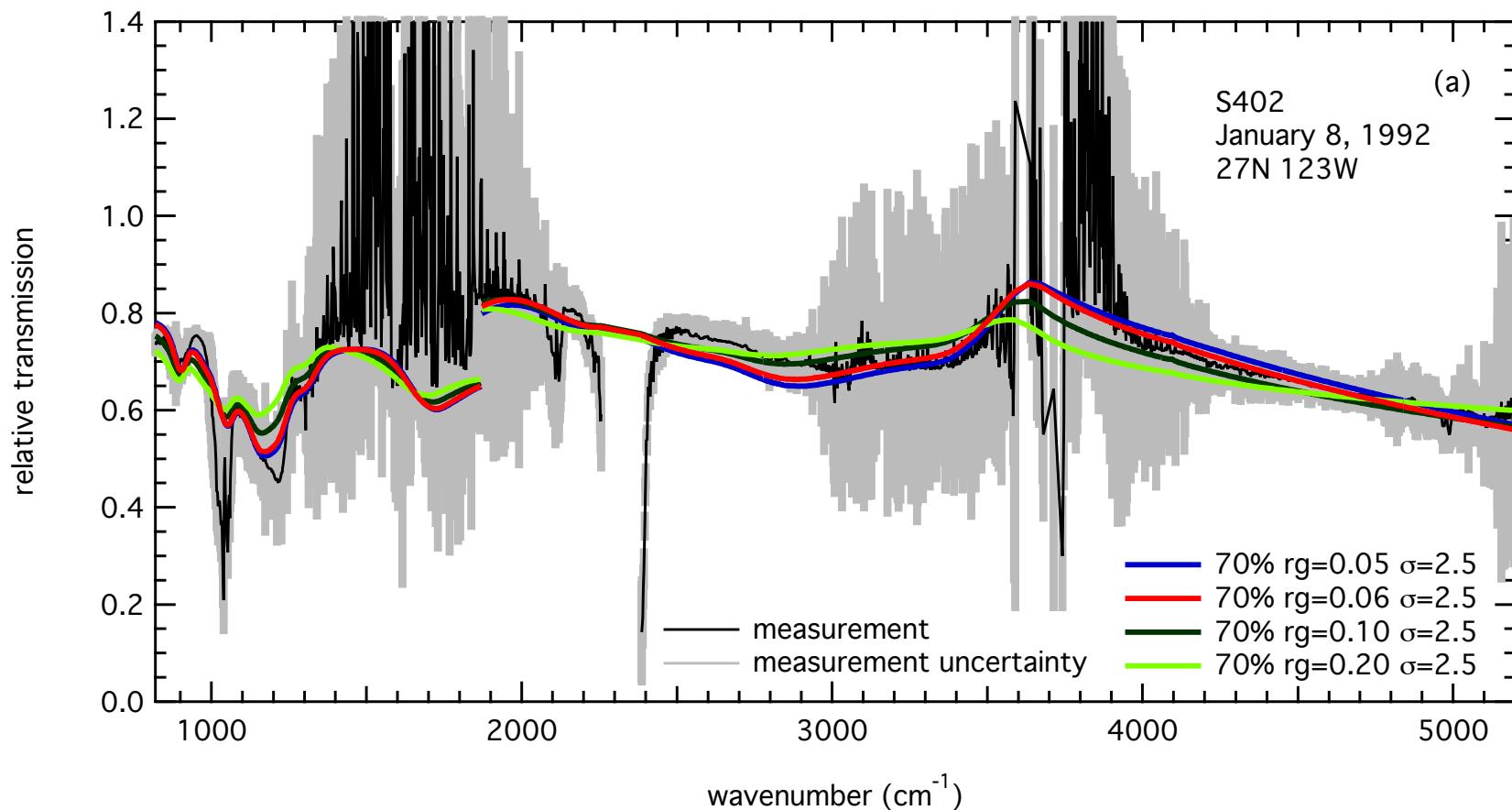
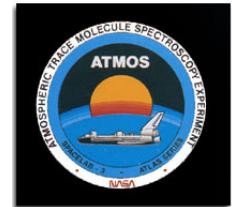
Aerosol models



- Set of lognormal size distributions with varying rg and sigma
- Composition from 50 to 80%

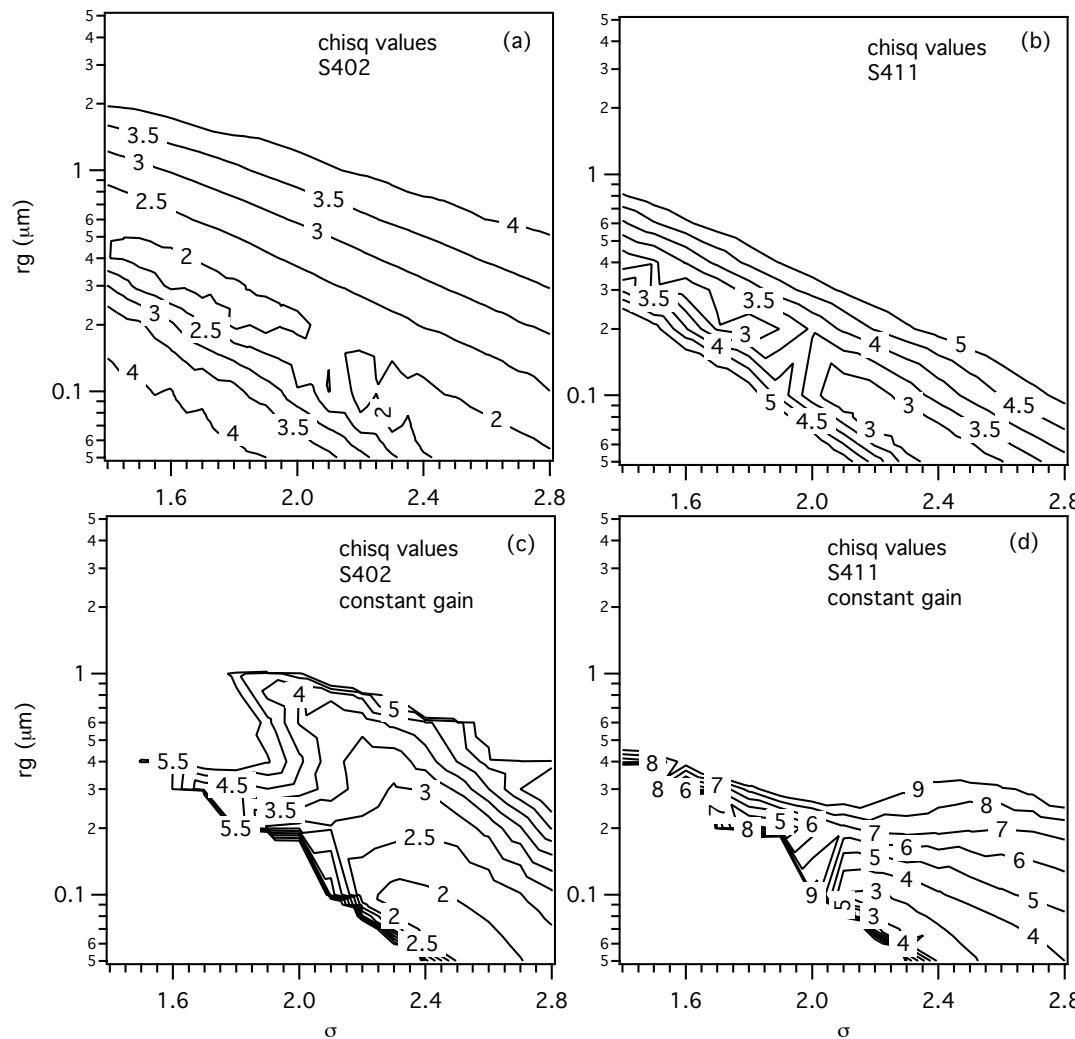


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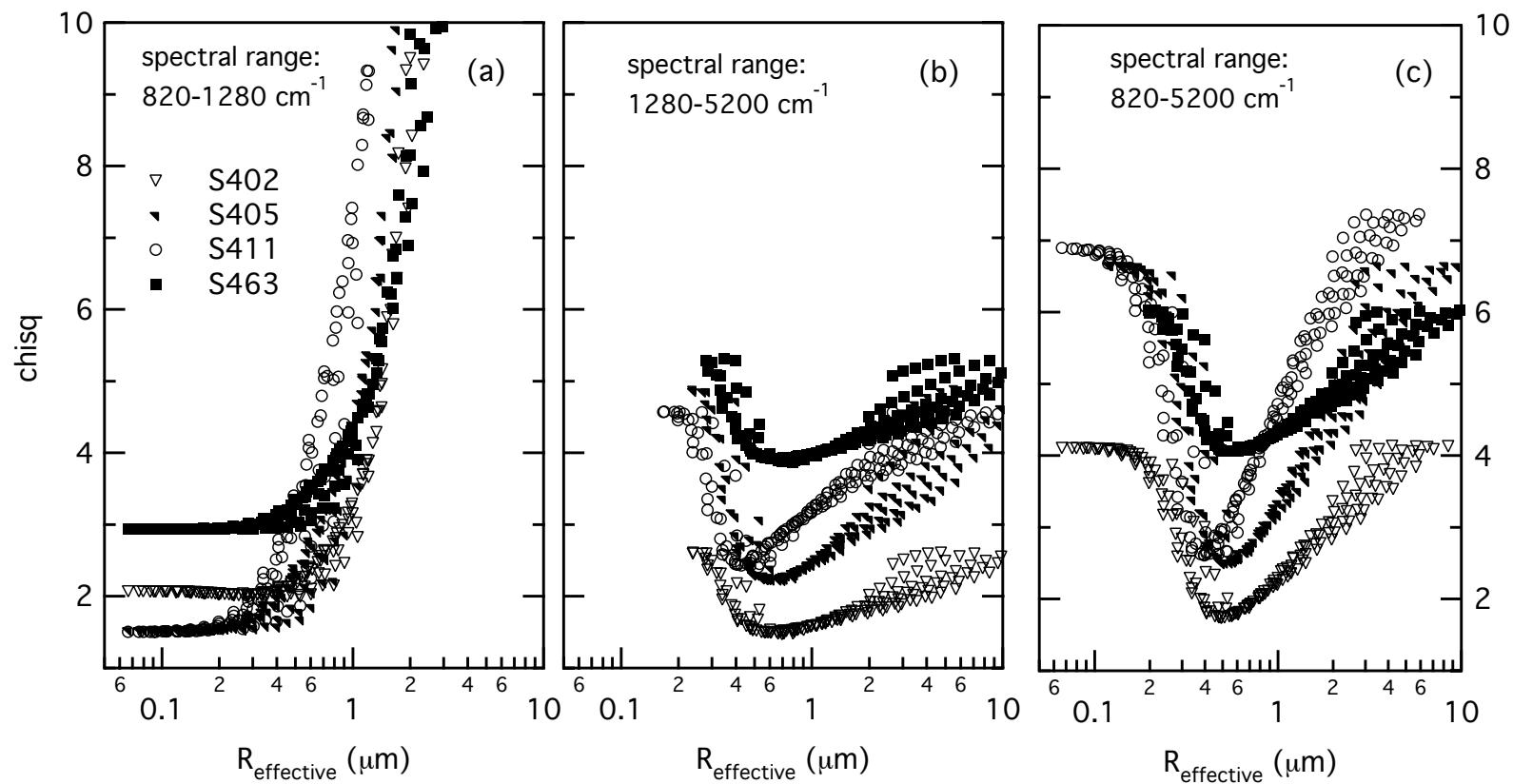
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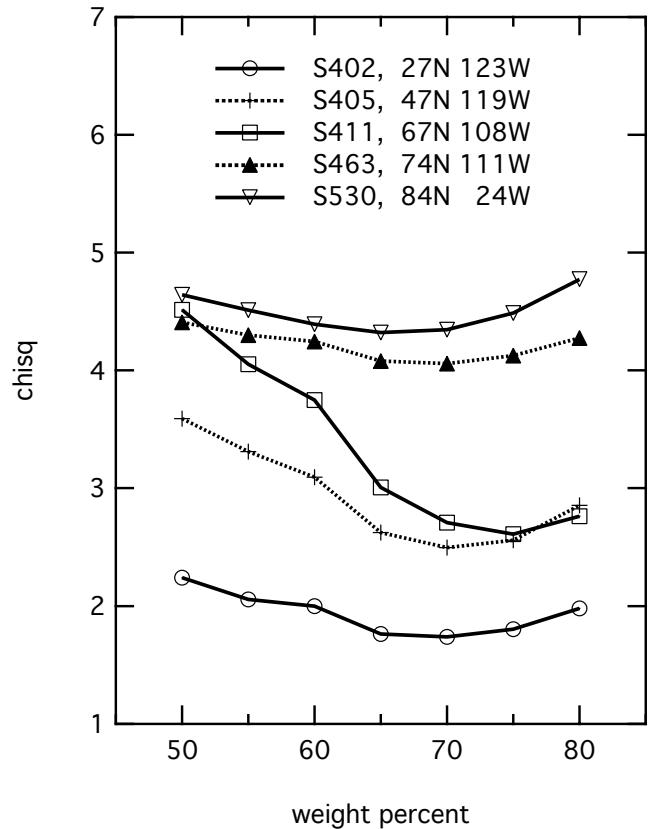


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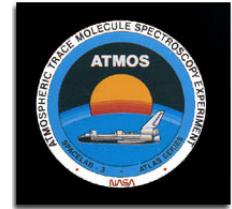


Size sensitivity





- Sensitivity to aerosol slant column
- Good size (r_{eff}) discrimination
- Limited sensitivity to composition



Applicability to ACE

- Techniques for extraction continua spectra are applicable
- Will have volume retrieval capability
- Wide band pass provides sensitivity to size
- If higher loadings occur, will have composition sensitivity
- Challenge to create operational retrieval
- Precomputed aerosol models and focused spectral regions should be feasible



Summary

- Instrument details and viewing geometry influence sensitivities
- MkIV - good size sensitivity due to wide bandpass
- ATMOS - good sensitivity to loading and composition
- Capabilities limited with low aerosol concentrations
- The ACE instruments with its wide bandpass will offer advantages!